

## TOUCH-SENSITIVE DATA INPUT DEVICE

## BACKGROUND OF THE INVENTION

This invention relates generally to data input devices and particularly to touch-sensitive apparatus used in conjunction with computer data display screens.

Interactive computer systems usually require an operator to observe data displays on a cathode ray tube or other display screen and to enter data on a keyboard. While keyboards are suitable for entry of large amounts of character-oriented data, they have disadvantages in many applications—especially those contemplated for microcomputers. Keyboards require training for efficient use and many microcomputer users have not had such training, nor are they inclined to take it. Moreover, with a keyboard, the data display and data entry functions are separated both spatially and conceptually. It is sometimes difficult for an operator to associate display and input functions in a natural way when they are separated by such a physical and perceptual distance.

Touch-sensitive display screens have been proposed to alleviate the problems of using keyboards for data entry in some applications. Typically such screens consist of a plurality of light emitters and detectors arranged around the sides of the display screen so that they cover the display surface with crossed light beams. Touching the display surface with a finger or pointer breaks one or more of the beam allowing the apparatus to calculate the position of the touch. In an interactive computer system, therefore, the computer can display information on the screen and the operator can make selections, confirm data or otherwise input data by touching the appropriate point on the screen.

Such an apparatus requires carefully collimated light beams in order to provide unambiguous position measurement. Such collimation requires bulky optical arrangements that limited acceptance of light beam touch screens. To eliminate the requirement for collimation, only a few, widely separated light beams in each orthogonal direction are energized at a time. This is done by enabling the emitters and detectors by pairs in sequence. If this is done quickly enough, the effect is the same as if a grid of beams covers the screen continuously.

In this type of apparatus, accurate position sensing depends on the accurate and unchanging spatial relationships between emitters, detectors and the display screen. Once the apparatus has been calibrated, the user must be confident that these relationships cannot change significantly over time. This typically has meant that the touch detecting apparatus must be built into the display screen housing. While this is satisfactory in many applications, users who already have display screens without touch-sensitive input capability cannot have the benefit of such data input means without replacing their display screens. In addition, the touch-sensitive input apparatus cannot be removed easily for cleaning and maintenance.

Further, to maintain the alignment of the emitters and detectors, they have been rigidly attached to a sheet of transparent material which is mounted in front of the display screen and through which the beams propagate. While this avoids the problem of misalignment, it does so at the cost of interposing a material between the display screen and then observed with the consequent possible loss of brightness and contrast.

## SUMMARY OF THE INVENTION

The present invention provides a touch-sensitive data input device for use with a computer system having a display screen. The device includes a demountable bezel for establishing a grid of light beams in front of the display screen. As used herein, the term "demountable" means that the bezel is not built into the display screen housing, but rather it is removable from one display screen and can be mounted to a different display screen or remounted to the same display screen.

The device also includes means for determining the grid coordinates of an object placed proximate the face of the display screen to interrupt the light beam grid and thereby mark a spot on the screen, and means coupled to the grid coordinate determining means for reporting the grid coordinates to a central processing unit of the computer system.

The problem of misalignment of the bezel light beam grid coordinates and the display screen coordinates is overcome by provision of an alignment routine executed by the computer in which coordinate transforms are generated to translate bezel light beam coordinates to display screen coordinates. This is accomplished by the CPU of the computer system under the direction of a program of instruction stored in memory and involves displaying a spot on the display screen at a location with known coordinates and the frame of reference of the display screen; accessing the bezel grid coordinates generated by an interruption of the light beam grid by an object placed at the location of the spot on the display screen, to obtain coordinates of the spot in the frame of reference of the bezel grid; and calculating coordinate transforms to be applied to the bezel grid coordinates to effectively align the bezel frame of reference to the display screen frame of reference.

## BRIEF DESCRIPTION OF THE DRAWINGS

A written description setting forth the best mode presently known for carrying out the present invention, and of the manner of implementing and using it, is provided by the following detailed description of a preferred embodiment illustrated in the attached drawings wherein:

FIG. 1 is an overall view of an embodiment of the touch-sensitive device's bezel assembly of the present invention;

FIG. 2 is a cross-section of the bezel assembly illustrating the mounting of light-emitting diodes and detectors on opposite sides of a computer display screen;

FIG. 3 is a diagram of circuitry that drives the light-emitting diodes and enables the detectors in the bezel;

FIG. 4 is a timing diagram showing the output of the counter in the bezel driver circuitry;

FIG. 5 is a block diagram of the circuitry that decodes the position of the touch and reports it to the computer;

FIG. 6 is a flow chart of the algorithm used to align the bezel on the screen for accurate and repeatable position encoding; and

FIG. 7 is a diagram of a computer system illustrating use of the touch-sensitive data input device.

## DETAILED DESCRIPTION

## A. Bezel Assembly

Touch-sensitive apparatus in accordance with the present invention generally includes a bezel assembly, a bezel controller and a program of instructions for di-